requirements of 37 C.F.R. §1.121(b)(1). Accompanying this *Preliminary Amendment* is Appendix I in which a marked-up copy of the amended paragraph(s) is provided showing all changes (i.e., with deletions enclosed in brackets and additions underlined), pursuant to 37 C.F.R. §1.121(b)(1)(iii).)

PAGE 5: Replace the second full paragraph on page 5 with the amended paragraph that appears below.

A1

FIG. 1 is wire model of a phased array neurovascular coil 50, also referred to herein as a neurovascular array coil. The neurovascular array coil 50 contains four separate imaging coils. The first coil is a quadrature tapered birdcage 60 covering the brain and head. Further details regarding the quadrature tapered birdcage are provided in U.S. Application Serial No. 09/449,256, filed November 24, 1999, now issued as U.S. Patent 6,344,745, the contents of which are incorporated herein by reference. The first coil may alternatively be in the form of a domed birdcage, such as is described in U.S. Patent 5,602,479, the contents of which are incorporated herein by reference, although the tapered birdcage is preferred because it provides improved field homogeneity on the XZ and YZ image planes.

PAGE 6: Replace the first full paragraph on page 6 with the amended paragraph that appears below.

A2

FIGS. 2A and 2B are electrical schematics of a coil interface circuit 100 that provides multimode operation of the phased array neurovascular coil 50 shown in FIG. 1. The coil interface circuit 100 couples the phased array neurovascular coil 50 to a magnetic resonance imaging (MRI) system. The coil interface circuit 100 has a number of signal input ports 102, which are coupled to receive magnetic resonance (MR) signals from the phased array neurovascular coil 50. As shown in FIG. 2A, signal inputs 102 are coupled to output ports (e.g., port #2, port #3, port #4, port #5, and port #6), which are in turn coupled to predetermined MRI system receivers. Many systems, including the GEMS Signa® MRI system, provide only four receiver channels. Thus, because not all the signal inputs 102 can be simultaneously applied to the MRI system when the number of potential signal inputs 102 exceeds the number of available receivers, the interface circuit 100 allows selected signal inputs 102 to be coupled to the MRI system receivers.

A5 End

described in further detail below. For these alternative modes of operation, unless otherwise noted, the design of coil interface 100 shall allow the cervical spine coils 70 to be applied separately to the coil interface, rather than being combined at the RF level.

[PAGE 10: Replace the third full paragraph on page 10, and its] associated title, with the amended paragraph that appears below.

HIGH RESOLUTION BRAIN AND CERVICAL SPINE Mode

A6

This mode activates the head and posterior cervical spine coils 60 and 70, and disables the anterior neck coils 80 and 90. This allows focal studies of the brain, brain stem, spinal cord, and cervical spine. The two quadrature components of the MR signal from the birdcage coil 60 each drive a separate receiver channel for optimum uniformity and signal to noise ratio performance. The combiner circuit for birdcage coil 60 is electrically disconnected to allow independent reconstruction of the data from the two channels. Similarly, the two posterior cervical spine coils 70 also each drive a separate receiver channel.

[PAGE 10: Replace the fourth full paragraph on page 10, and its associated title, with the amended paragraph that appears below.]

CERVICAL SPINE Mode

In CERVICAL SPINE mode, the two quadrature components of the MR signal from each of the two posterior cervical spine coil elements 70 each drive a separate receiver channel for optimum uniformity and signal to noise ratio performance. The head coil element 60 and the anterior neck coils 80 and 90 are electrically disabled to minimize artifacts and undesirable coil interactions.

PAGE 11: Replace the first full paragraph on page 11, and its associated title, with the amended paragraph that appears below.

A7 cont

VOLUME NECK Mode

This mode disables the tapered birdcage coil 60 covering the head region, and activates the spine region coils to form a volume acquisition of the neck region. The two quadrature components of the MR signal from each of the two posterior cervical spine coil elements 70

PAGE 8: Replace the third full paragraph on page 8 with the amended paragraph that appears below.

A3

FIG. 3 is a wire model of the phased array neurovascular coil 50 in NEUROVASCULAR mode. As noted above and shown in FIG. 3, all elements of the phased array neurovascular coil 50 are activated and the MRI system operates in the phased array mode. The NEUROVASCULAR mode may essentially be used for all types of brain and neck imaging. The NEUROVASCULAR mode is particularly useful for brain and/or cervical spine localizers, imaging of the cervical spine, imaging of the carotid arteries, and imaging of the aortic arch. As shown in FIG. 3, this mode of operation advantageously provides a field of view of up to 46 cm.

PAGE 9: Replace the second full paragraph on page 9 with the amended paragraph that appears below.

A4

FIG. 4 is a wire model of the phased array neurovascular coil in HIGH RESOLUTION BRAIN imaging mode. As shown in FIG. 4, only the quadrature birdcage coil 60 is activated; the cervical spine coils 70 and the anterior neck coils 80 and 90 are electrically disabled. The MRI system operates in phased array mode. The HIGH RESOLUTION BRAIN imaging mode may essentially be used for all types of brain and/or head imaging but is especially useful for high resolution studies of the brain. The HIGH RESOLUTION BRAIN imaging mode is also useful for high resolution Circle of Willis imaging. As shown in FIG. 4, this mode of operation provides a field of view of up to 24 cm.

PAGE 10: Replace the second full paragraph on page 10 with the amended paragraph that appears below.

A5 cont

Additional modes of operation for the phased array neurovascular coil 50 can be realized by providing the MRI system with the appropriate port masks for the coil interface 100. For example, the phased array neurovascular coil 50 may also acquire images when operated in one or more of the following modes: HIGH RESOLUTION BRAIN AND CERVICAL SPINE, CERVICAL SPINE and VOLUME NECK. Each of these modes is

A7 End

and the anterior neck coils 80 and 90 each drive a separate receiver channel for optimum uniformity and signal to noise ratio performance. Alternatively, the MR signals from the two posterior cervical spine coils 70 are combined at the RF level and applied as a single input to the coil interface 100, along with the two MR signals from the anterior neck coils 80 and 90.

Please amend the following four ***sections*** of the application to read as follows. Be advised that the OBJECTIVES OF THE INVENTION section is new to the application but does not add new matter. This is because the text contained therein was taken directly from the original summary section. (These sections have been amended in the manner required by 37 C.F.R. §1.121(b)(2). Accompanying this *Preliminary Amendment* is Appendix II in which a marked-up copy of the amended sections is provided showing all changes (i.e., with the deleted portions bracketed and the additions underlined), pursuant to 37 C.F.R. §1.121(b)(2)(iii).)

A8 cont

CROSS-REFERENCE TO RELATED APPLICATIONS

The invention described in this patent application is closely related to the following patent application: MULTIMODE OPERATION OF QUADRATURE PHASED ARRAY MR COIL SYSTEMS, U.S. Serial No. 09/449,255, filed November 24, 1999, now U.S. Patent 6,356,081, which was granted March 12, 2002. The present application, and the above cited parent application on which it is based, claim the benefit of U.S. Provisional Application No. 60/109,820, filed November 25, 1998.

BACKGROUND OF THE INVENTION

The advantages of using phased array or multi-coil magnetic resonance (MR) coil systems to enhance magnetic resonance imaging and spectroscopy are well known. A situation facing the designer of such coils is the finite number of available simultaneous data acquisition channels in the host magnetic resonance imaging (MRI) system. Frequently, there are only four such channels, sometimes known as receivers, available in the host MRI system.

Another issue is the time it takes to reconstruct the images from the collected data. Processing multiple channels to form a single image increases the time needed by the MRI system to process the data, by two or three-dimensional Fourier Transform techniques or other methods, and ultimately to create the final images. Another consideration is that data acquisition hardware with additional performance capabilities may only be available on one receiver, or at least on fewer than the total number of available receivers.

Reconstruction of an image from two quadrature modes of a specific phased array coil element via two separate data acquisition channels provides the best possible image signal-to-noise ratio and uniformity, as the data can always be reconstructed in the most optimum way in such a scenario. However, the use of two separate receivers for the two quadrature signals from a specific phased array coil element may cause problems with reconstruction time, or limitations due to the finite number of available receivers. Thus, there may be conditions when combining the two quadrature signals at the radio frequency (RF) level into a single signal may be most advantageous, and other times when processing the two RF signals independently via two separate data acquisition receivers may be the best scheme.

OBJECTIVES OF THE INVENTION

It is, therefore, an objective of the invention to provide a coil interface that allows the two quadrature magnetic resonance (MR) signals from one or more coil elements of a phased array coil system to be acquired as a single signal (combined at the radio frequency (RF) level within the coil interface) by one receiver channel of the host MRI system or as two separate RF signals by two receivers of the MRI system.

Another objective is to provide a coil interface that allows the mode of operation for the phased array coil to be remotely selected from the operator's console of the host MRI system.

SUMMARY OF THE INVENTION

In one presently preferred embodiment, the invention provides a coil interface for coupling a phased array coil system to a host magnetic resonance imaging (MRI) system. The host MRI system has a number of receiver channels for receiving magnetic resonance (MR) signals, and the phased array coil system has a plurality of coil elements. The coil interface comprises a plurality of input ports, a plurality of output ports, and an interface circuit. The input ports are adapted to be coupled to the plurality of coil elements. The output ports are

A8 End

adapted to be coupled ~~to~~ the receiver channels of the host MRI system. The interface circuit allows selective interconnection of at least two of the input ports to at least one of the output ports, thereby allowing the phased array coil system to be selectively operated through the host MRI system in any one of a plurality of operational modes during an MRI scanning procedure.

In a related aspect, the invention provides a method of operating a phased array coil system in a plurality of operational modes. The phased array coil system has a plurality of coil elements capable of operating with a host magnetic resonance imaging (MRI) system during an MRI scanning procedure. The method comprises the steps of providing and selectively configuring an interface circuit. The former step involves providing an interface circuit that has (i) a plurality of input ports for coupling to the coil elements and (ii) a plurality of output ports for coupling to a number of receiver channels of the host MRI system. The later step involves remotely configuring the interface circuit to selectively interconnect at least two of the input ports to at least one of the output ports, thereby allowing the phased array coil system to be selectively operated through the host MRI system in any one of the operational modes during an MRI scanning procedure.

BRIEF DESCRIPTION OF THE DRAWINGS

The preferred embodiments of the present invention are illustrated by way of example, and not limitation, in the figures of the accompanying drawings, in which:

FIG. 1 is a wire model of a phased array neurovascular coil;

FIGS. 2A and 2B are electrical schematics of a coil interface circuit that provides multimode operation of the phased array neurovascular coil shown in FIG. 1;

FIG. 3 is a wire model of the phased array neurovascular coil in a first operational mode;

FIG. 4 is a wire model of the phased array neurovascular coil in a second operational mode; and

FIG. 5 is a wire model of the phased array neurovascular coil in a third operational mode.